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ScienceDirect
Procedia - Social and Behavioral Sciences 140 (2014) 37 – 42
Procedia Social and Behavioral Sciences

PSYSOC 2013

Children's Imitation With Varied Demonstration And Reproduction Delays

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Abstract

Imitation is both a simple (Fadiga et al., 1995) and a complex matching (Wohlschläger et al., 2003) for transforming visual inputs into motor outputs. These matching types determine what and how observed behaviors would be matched and imitated. The current study tests the children's ability to imitate transitive and intransitive action's course demonstrated by an adult model involving necessary and unnecessary sequences for performing goal-directed actions immediately or after varied delays. The goal-directed actions imitation is depended on imitation form (Labiadh et al., 2013) and calling (Meltzoff & Moore, 1998) process. For instance, in immediate imitation, the ability to recall is easy and requests a low memory load (Wohlschläger et al., 2003). In short-term deferred imitation, the delay between demonstration and reproduction is short and the retention of actions is limited and requests a short-term memory (Rumiati & Tessari, 2002). While, in long-term deferred imitation, the demonstration and reproduction delay is long and requests a long-term memory (McDonough et al., 1995).

Selection and peer-review under responsibility of the Organizing Committee of PSYSOC 2013.

Keywords: demonstration, reproduction delay, imitation.

Introduction

Recalling and imitating observed behaviors would also depend on certain factors. The first one concerns the goals and means process. Wohlschläger et al. (2003) demonstrated that the model's action-goal was imitated correctly but the means (e.g., how to touch the ear) were neglected and considered as unnecessary for goal. The second factor concerns the nature of observed behavior. Rumiati & Bekkering (2003) showed that healthy individuals imitated better meaningful actions than meaningless ones, because they had a concrete goal. The third factor concerns the encoding and memory systems (White et al., 2009). For example, in certain imitation form, imitator is not informed

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Selection and peer-review under responsibility of the Organizing Committee of PSYSOC 2013.
doi:10.1016/j.sbspro.2014.04.383

of what he/she will have to reproduce later. In such a case, incidental encoding is susceptible to intervene in short-term memory because he/she does not expect a further imitation test. In other imitation form, the imitator is informed about later reproduction. In such a case, intentional encoding is susceptible to intervene in long-term memory because he/she is warned to a further imitation test.

The alignment of these factors (e.g., incidental *versus* intentional encoding, short-term *versus* long-term deferred imitation and meaningful *versus* meaningless actions) determines the involvement of cognitive resources. Tessari et al. (2007) explained the decline of meaningless actions imitation both in apraxic patients and healthy individuals by a breakdown of the direct route and by reduced cognitive abilities. De Agostini et al. (1996) found in testing demonstrated action items in 3- to- 8-year-old children that, the recalling performance increased from 2 items in 3-year-olds to 5 items in 6-year-olds and to 6 items in 8-year-olds. The recalling ability governed by a chunk process allowing the decomposition of actions, events, or objects on sequences (Schank, 1982; Schank & Abelson, 1997; Verwey, 1996).

In testing the imitation of transitive and intransitive actions course, it was first predicted that all age groups accomplished the goal-directed actions by respecting only the necessary sequences, whereas the unnecessary ones would be neglected or forgotten. Second, it was predicted that the imitation form and age would determine the involvement of encoding and memory systems to accurately imitate the demonstrated course.

2. Method

2.1. Participants

Eighty-five healthy children were divided into five groups between exactly 3 years 5 months and 7 years 5 months of age, respectively and asked by a human adult model to reproduce a composed intransitive and transitive actions course. Each age group comprised 17 children (M = 5.5 year-olds, range = between 3.5 and 7.5-years of age). The parents of all children signed an informed consent form to participation of their children.

2.2. Apparatus and procedure

Children were tested in their school sports room. Videotape equipment, namely a JVC VHS/DV digital video camera operated by a cameraman was set up to film their executions. The adult model individually asked each child of each age group *to observe and do alone the same course he had just done*. Child had to start with both feet in circle N°1 and walked on the first two obstacles. Upon arriving on the second obstacles, he/she jumped into circle N°2 situated between two symmetrically placed boxes. Each box contained one umbrella. A container was placed behind each box with four tennis balls in it. From circle N°2, he/she turned the body to the right-hand side, took two tennis balls in the right container, carried them to the left side, and put them in the left-hand side container. With both feet still in circle N°2, he/she opened the right hand-side box, picked up the umbrella, and carried it to the left side. With the umbrella, he/she pointed to three holes drilled in the box, and afterwards he/she put the umbrella inside the left box. From circle N°2, he/she walked and jumped between the last two obstacles and landed on both feet, into circle N°3.

Each child of each age group individually performed in three different imitation forms over two separate experimental series. The first series was reserved for two successively realized imitation forms in the same day:

(1) Immediate and simultaneous imitation (ISI): the adult model and the child were positioned side by side. The adult model asked each child of each age group to observe and perform at the same time and in the same direction, but each in his own course. Each child had one trial. This imitation did not require a recalling mechanism.

(2) Short-term deferred imitation (STDI): just after finishing the previous imitation, the adult model invited each child of each age group to reproduce alone the same course without accompanying him/her. Each child had one trial. This imitation would require a short-term memory using an incidental encoding because he/she did not expect a further test.

(3) The second series of tests was reserved for the long-term deferred imitation (LTDI) during six successive sessions (one session per week). Each child of each age group was individually asked to reproduce alone the course, after each adult model's demonstration at each session without observing others. This imitation would require a long-term memory using an intentional encoding because he/she was warned to reproduce later.

2.3. Data collection and statistical analysis

The children's filmed responses were coded in dichotomous data (1–0). The response was scored as "1" if he/she performed the modeled actions and as "0" if he/she absolutely did not imitate them. For example, if he/she performed walking or reaching an object, his/her response was coded as "1" (recalling), and when he/she did not, his/her response was coded as "0" (forgetting). Also, if he/she reached the umbrella without opening the box, the response was coded as "1" because he/she respected the end-goal: holding the umbrella for pointing with it, and as "0" if he/she pointed in the same box where he/she reached the umbrella because he/she considered the carrying sequence as unnecessary for accomplishing the goal.

The statistical process of dichotomous data mobilized specific methods. The dichotomous codes did not share out according to a normality law, and thus did not allow the normality test. Therefore, it was necessary to use a log-transformation of performances to apply an adequate ANOVA. The most frequently used transformation was "angular transformation in percentage" (Lellouch, 1996). The statistical significance was set at $p < 0.05$. A post hoc *Reduced Distance test* was carried out for measuring the significant effect of variables with more than two levels to determine what this effect should be ascribed to.

The dependent variable was the children's recalling scores (%) and the independent variable was the three imitation forms. For the first series of imitation, the analysis was a two-factor ANOVA. The independent factors were: age-group (five: 3.5 to 7.5-year-olds), -imitation form (two: immediate and simultaneous imitation, short-term deferred imitation). For the second series of imitation, the analysis was a two-factor ANOVA, the independent factors were -age-group (five: 3.5 from 7.5 years), -long-term deferred imitation.

3. Results

3.1. Necessary sequences for goal accomplishment

3.1.1. Intransitive movements: walking and jumping

All age groups recalled and performed the intransitive locomotion movements (recalling performance: 100%), in all imitation forms (ISI, STDI, LTDI).

3.1.2. Transitive actions with objects: ball and umbrella sequences

– In immediate and simultaneous imitation, all age groups recalled and performed the ball and umbrella sequences (recalling performance: 100%).

– In short-term deferred imitation, ANOVA showed a significant effect of age: $F(4, +\infty) = 18.43$, $p < 0.0001$ in ball sequences. The *Reduced Distance test* attributed the difference to the 3.5 and 4.5 age groups, who recalled worse (33%, 36%) than the older ones (5.5: 65%, 6.5: 83% and 7.5-year-olds: 98%). ANOVA also showed a significant effect of age: $F(4, +\infty) = 12.22$, $p < 0.0001$ in umbrella sequences. The *Reduced Distance test* revealed that the recalling performances of the younger age groups (3.5: 33%, 4.5-year-olds: 50%) were inferior to those of the older ones (5.5: 74%, 6.5: 77% and 7.5-year-olds: 97%).

– In long-term deferred imitation, ANOVA showed a significant effect of age: $F(4, +\infty) = 10.69$, $p < 0.0001$ in ball sequences. The *Reduced Distance test* attributed the difference to the 3.5 age group by recalling less (82%) than the other age groups (4.5: 97%, 5.5: 90%, 6.5: 95% and 7.5-year-olds: 94%). ANOVA also showed a significant effect of age: $F(4, +\infty) = 3.18$, $p < 0.05$ in umbrella sequences. The *Reduced Distance test* attributed the difference to the 3.5 age group by recalling less (83%) than the other age groups (4.5: 97%, 5.5: 98%, 6.5: 98% and 7.5-year-olds: 96%).

3.2. Unnecessary sequences for goal accomplishment

3.2.1. Body turning and umbrella carrying

– In immediate and simultaneous imitation, ANOVA did not show a significant effect of age: $F(4, +\infty) = 1.42$, $p > 0.05$ in the body turning sequence. While, the same analyses showed a significant effect of age: $F(4,+\infty) = 3.50$, $p < 0.001$ in the umbrella carrying sequence. The *Reduced Distance test* revealed that the 3.5, (35%), 4.5 (44%) and 5.5 (38%) age groups recalled less these sequences than the 6.5 (73%) and 7.5 (53 %) age groups.

– In short-term deferred imitation, ANOVA showed a significant effect of age: $F(4, +\infty) = 8.98$, $p < 0.0001$ in the body turning sequence. The performance of the 3.5 (9%) and 4.5 (21%) age groups were inferior to those of the other age groups (5.5: 41%, 6.5: 38% and 7.5-year-olds: 68%). The same analyses also showed a significant effect of age: $F(4, +\infty) = 2.81$, $p < 0.05$ in the umbrella carrying sequence. The *Reduced Distance test* revealed that the 3.5 (26%) and 4.5 (21%) age groups recalled less than the other age groups (5.5: 32%, 6.5: 38% and 7.5-year-olds: 56%).

– In long-term deferred imitation, ANOVA showed a significant effect of age: $F(4, +\infty) = 17.61$, $p < 0.0001$ in the body turning sequence. The *Reduced Distance test* attributed the difference to the 3.5 age group. They recalled less (45%) than the other age groups (4.5: 63%, 5.5: 69%, 6.5: 74% and 7.5-year-olds: 77%). ANOVA also showed a significant effect of age: $F(4, +\infty) = 60.40$, $p < 0.0001$ in the umbrella carrying sequence. The *Reduced Distance test* attributed the difference to the 3.5 and 4.5 age groups. They recalled less (35%, 46%) than the other age groups (5.5: 81%, 6.5: 82% and 7.5-years: 84%).

4. Discussion

4.1. Necessary sequences for goal accomplishment

As predicted, all age groups accomplished with higher accuracy the modeled-goal actions. The results are consistent with the literature showing that animals and humans segment the flow of actions on goals (Byrne & Russon, 1998; White *et al.,* 2009). This enhances the idea that in early stage of life, children are able to perform the goal-directed actions (Meltzoff, 1995; Csibra, 2003). It is agreed that, at least by the middle of the first year of life, infants construct the actions seen on other persons in goal-directed ways (Southgate *et al.,* 2008). Nevertheless, the accomplishment of goals varied according to the nature of action.

The walking and jumping movements were easily retained and reproduced by all age groups in all imitation forms (100% recalling). The intransitive locomotion movements probably require fewer cognitive resources than the ones involved in a stable body (Labiadh *et al.,* 2010). This is in agreement with Berthenthal's (1996) assumption that recognition of action changes whether children produce stable or dynamic body movements. The locomotion movements might merely reflect a primacy / regency effect (Travis, 1997). In other words, what was better recalled here concerned mostly the first and last movements, namely walking and jumping, probably requesting heavy demands on memory.

Contrary to intransitive movements, the transitive actions were encoded differently according to the age and imitation form. These actions with objects were significantly less recalled in the 3.5 and 4.5 age groups in short-term deferred imitation, while they were already encoded in immediate and simultaneous imitation, because the adult model accompanied the children's reproduction. Cognitive resources such as planning or recalling did not have any impact on their performance in this imitation form. The child performed step by step favored by the model's guidance and also by the physical presence of objects (e.g., container, balls, box, or umbrellas). The restoration of these chunks in actions with objects was governed by a short-term memory in short-term deferred imitation, and by a long-term memory in long-term deferred imitation (Labiadh *et al.,* 2013). Recently, Carmo and Rumiati (2009) found that imitation performance among adults engaged in a speed imitation task was significantly poorer when meaningful gestures involved object (e.g., hammering with an imaginary hammer), rather than no objects (e.g., waving good-bye), suggesting that the use of objects increases processing demands. It seems more likely that transitive actions pose greater processing demands on the cognitive system, because they intrinsically more complex due to their association with the object representation (Press *et al.,* 2008).

4.2. Unnecessary sequences for goal accomplishment

Generally, children do not integrate all details of demonstrated behaviors. As predicted, the unnecessary sequences to pursue the goals were connected to particular chunks. In fact, all age groups considered the sequences of body turning and umbrella carrying as not useful for accomplishing goals. He/she could for example, reach the balls, or open the box to grasp the umbrella without changing sides. Those sequences were less goal-directed and the lower recalling rates found in short-term imitation continued to exist in long-term one, even in the older age groups (Labiadh *et al.,* 2013). If those two sequences are neglected in short-delay retention, this signifies that information do not encoded and is forgotten in long-delay retention. Because the child can for example, stay in the left side after being put the balls for reaching the umbrella without turning his/her body or he/she can point in the side who he/she reaches the umbrella without carrying it to the opposite side. The two sequences were therefore unnecessary for goals, as was the case for the meaningless *versus* meaningful actions to imitate the final outcome (Rumiati & Tessari, 2002). The number of sequences could also affect the imitation of action goals, because the imitation performance is often affected by a limitation of cognitive resources, such as the working memory (Wohlschläger *et al.,* 2003). The children have small working memory capacity, and hence they disregard other aspects of movement.

When the size of the working memory is limited, only the goal is accurately reproduced, while its details is neglected.

The second hypothesis predicted that the imitation form and age would determine the involvement of encoding and memory systems to accurately imitate the demonstrated course. Our results also confirmed this prediction. For example, in long-term deferred imitation, the younger age groups increased their recalling performances compared with those scored in short-term one. The younger age groups with important success retained the ball and umbrella actions because they were with important perceptual salience. The object carrying sequences were orchestrated according to the actions' sense. For example, it is too silly to reach balls in a container and then put them into the same container. Indeed, there was no child, which behaved like this, because it did not serve the final goal. However, reaching an umbrella in a box and pointing with it into the same box is quite consistent with the end-state-goal (Byrne & Russon, 1998). Interestingly, in long-term deferred imitation, children regrouped the actions in structured hierarchical goals. They also succeeded in categorizing three structured chunks: (1) locomotion movements (two sequences); (2) ball (three sequences); (3) umbrella (five sequences). Chunk is believed to be one of the earliest forms of acknowledged representations used to regroup objects, persons, or events (Nelson, 1986). The construction of these chunks was compatible with the Travi's (1997) results demonstrating that, from the age of two, children start interleaved pairs of three-step action sequences by chunking together, performing them in a temporally continuous sequence.

In summary, our results demonstrate that children organize actions hierarchically to guide their imitation. They selected in priority the necessary sequences, while they ignored the unnecessary ones to accomplish goals. When reproduction was intentional in long-term deferred imitation, rather than incidental in short-term imitation, they increased their likelihood to build a strong and lasting recall level by establishing elaborate encoding system. Recalling is influenced by the nature of actions (intransitive *versus* transitive), usefulness of action sequences (necessary *versus* unnecessary), imitation form (immediate *versus* delayed), and children's age (from 3.5 to 7.5 years). These findings expand the point of view that perceiving movements or actions undergoes a decomposition-decomposition process.

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